THE EFFECTS OF SEVERAL HERBICIDES

ON EIGHT SUGARCANE VARIETIES

A THESIS SUBMITTED TO THE GRADUATE SCHOOL OF THE

UNIVERSITY OF HAWAII IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF SCIENCE

IN AGRONOMY

FEBRUARY 1963

By

Robert Dale Wiemer

Thesis Committee:

Robert L. Fox, Chairman
Noel S. Hanson
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ABSTRACT

THE EFFECTS OF SEVERAL HERBICIDES ON EIGHT SUGARCANE VARIETIES

Robert D. Wiemer

Since the introduction of 2,4-D compounds in 1945, many new herbicides have been tested in the Hawaiian sugar industry and several have been accepted for commercial use. Much has been learned about the weed control activity of the different herbicides, but little has been learned about their affect on sugarcane varieties. If more were known about the variation in response of sugarcane varieties to herbicides, better use might be made of several of the herbicides without inducing cane damage. Rates of herbicide application could be determined for tolerant or susceptible varieties, if other factors were equal, and recommendations could be made as to the safety of pre-emergence or post-emergence applications, singly, or in combination, for sugarcane varieties.

To determine whether or not varietal differences occur in response of sugarcane to herbicides, a three-factor experiment was installed using eight commercial sugarcane varieties and eight herbicides applied by four methods at one level of application. The herbicides used were monuron, diuron, linuron, atrazine, prometone, dalapon, amitrole, and 2,4-D. The methods were: (A) herbicide applied over exposed seed pieces; (B) herbicide applied over covered seed; (C) herbicide applied

over cane 20-30 inches tall; and (X) check, no herbicide applied.

Germination counts were made and analyzed. At approximately seven months of age all plots were harvested and the cane weighed. These weights were then subjected to analysis of variance. Weed control and cane effect ratings were made periodically.

Results indicated the variety factor to be the most important in both germination counts and harvest weights. Varieties which were inherently poor in germination and growth were most susceptible to herbicide damage. Three varieties exhibited high tolerance of herbicides as measured by germination counts, four were intermediate, and one was susceptible to damage. Six varieties exhibited relatively high tolerance of herbicides as measured by harvest weights. Two varieties were quite susceptible to herbicide damage.

Herbicides applied over exposed seed pieces (method A) tended to reduce germination. Post-emergence application over cane (method C) tended to decrease harvest weights. Normal pre-emergence (method B) was the least damaging treatment.

The most effective herbicides tested for pre-emergence weed control were atrazine and prometone, followed by monuron, diuron, and 2,4-D. Diuron and linuron were the most effective post-emergence weed control herbicides tested.

Observational gradings on cane effect agreed in general with those obtained for the analysis of harvest weights.

THE EFFECTS OF SEVERAL HERBICIDES ON EIGHT SUGARCANE VARIETIES

I. INTRODUCTION

Chemical weed control in the Hawaiian sugar industry began in 1913 upon the introduction of white arsenic with soda ash (6). Few herbicides were introduced during the next thirty years. In 1945 formulations of 2,4-D (2,4-dichlorophenoxyacetic acid) were introduced and marked the beginning of an active herbicidal era. During subsequent years, a large number of chemicals have been introduced and tested for weed control purposes with a relatively small number succeeding in commercial competition.

The basis for selection of the herbicides which succeeded was their ability to control weeds either by pre-emergence or post-emergence action and their factor of safety to the sugarcane plant. The ability of these herbicides to control weeds before or after emergence from the soil was established by field testing in Hawaii,[1] other parts of the United States and in foreign countries. Their factor of safety to the sugarcane plant has been studied but was not defined to the extent of their weed control abilities.

Sugarcane injury attributed to herbicides has ranged from mild chlorosis to severe stunting. Severe cases of injury may be found in localized areas and can usually be traced to misapplication of the

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[1]Since 1950 approximately 1300 tests involving over 140 herbicides have been conducted by the Experiment Station, HSPA.

herbicide or to unfavorable growing conditions, such as shallow soil or exposure of subsoils. Mild chlorosis, distortion, and stunting have occurred in field areas and have resulted in a decreased use of the herbicide in question in spite of its proven weed control ability. Recent studies (19) showed that soil adsorption may play an important role in herbicidal effects on sugarcane. Soils with a high adsorptive capacity have less herbicide available for the plant to take up than does a soil with a low adsorptive capacity. Other factors which may reduce or increase herbicidal damage to plants are volatilization, leaching, chemical or photochemical decomposition, and microbiological breakdown.

One factor which needs further study in the sugarcane industry is the varietal response to herbicides. Since variation in varietal response to herbicides was reported in corn (16), sorghum (7), wheat, oats (15), and barley (4), it is reasonable to expect it in sugarcane.

If varietal differences do occur in sugarcane in regard to application of a herbicide then it might be possible to recommend tolerant varieties over susceptible if other factors are equal. Precautions could also be stated for levels of herbicides to be used with varieties exhibiting susceptibility, and recommendations could be made as to the safety of pre-emergence or post-emergence applications singly or in combination.

This thesis reports the results of a three-factor, split-plot experimental test to determine effects on germination and green cane weights of eight sugarcane varieties when subjected to eight herbicides and four methods of herbicide application. Germination counts and green cane weights were analyzed and the results reported in a later section. Although of secondary interest, weed control ratings were also reported.

II. LITERATURE REVIEW

Herbicides used in the experiment are briefly reviewed as to their type and mode of action when known. A table of nomenclature for herbicides referred to in this thesis is to be found in Appendix Table 1.

Herbicide Review

Monuron: 3-(p-chlorophenyl)-1,1-dimethylurea

Monuron, a substituted urea compound, was introduced in 1951 and was one of the first major pre-emergence herbicides used in the Hawaiian sugar industry. Its principal mode of action is by root absorption and by transport upward into the plant in the transpiration stream (1). Monuron inhibits the release of oxygen in the photosynthetic process. Its effects on sugarcane are reduced tillering, chlorosis, and reduction in growth rate.

Diuron: 3-(3,4-dichlorophenyl)-1,1-dimethylurea

Diuron was introduced in 1953 and has since replaced monuron over many acres of sugarcane land. Its mode of action and effect on sugarcane is similar to that of monuron. Diuron is generally safer to use than monuron because of lower solubility (42 p.p.m. as compared to 230 p.p.m. for monuron) and because of limited leaching into the root zone (1).

Linuron: 3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea

At the time of test installation, linuron was an experimental herbicide showing some promise of use in the sugarcane industry. It has not been cleared for use in sugarcane and interest in this chemical has decreased. Linuron is also one of the substituted ureas with control qualities similar to, but no better than, diuron. Its mode of action has not been reported.

Atrazine: 2-chloro-4-ethylamino-6-isopropylamino-s-triazine

Atrazine is the second chemical in the s-triazine group of compounds to be cleared for use on Hawaiian sugarcane lands. It has replaced simazine, a closely related compound, because of a wider range of weed toxicity and length of control. Atrazine has a water solubility of 70 p.p.m. as compared to simazine with 5.0 p.p.m. (1). The triazines are the most effective against broadleaf weeds and small grass seedlings. Their mode of action is by root uptake. According to Gysin and Knusli (12, 13), a mechanism of action is the blocking of water photolysis and oxygen evolution. Corn is highly tolerant to this herbicide (1).

Prometone: 2-methoxy-4,6-bis(isopropylamino)-s-triazine

Another of the s-triazine compounds, prometone was an experimental herbicide at the time of test installation. It has since been replaced by other triazine compounds for testing as a potential commercial herbicide. It has a water solubility of 750 p.p.m. and can be absorbed and translocated by plant foliage as well as be taken up by root absorption (1).

Sodium Dalapon: sodium salt of 2,2-dichloropropionic acid

Sodium dalapon is a growth regulator which is most effective against grass plants as a foliage application but has been shown to be taken up by root absorption as well (9). This was confirmed by autoradiography work done by Crafts and Foy (2) which showed dalapon to move upward through the xylem and downward through the phloem after either root or foliar absorption. Dalapon causes stunting, excessive tillering, and a condition known as "tangle-top" when applied to sugarcane.

Amitrole: 3-amino-1,2,4-triazole

At the time of test installation, amitrole was an experimental herbicide. It has proven most effective on problem grasses and broadleaves such as Bermuda grass, Cynodon dactylon L Pers., and koa haole, Leucaena glauca. It is absorbed by roots or foliage of plants and freely translocated, but is used primarily for foliar application (1). A characteristic symptom of amitrole treated plants is extreme chlorosis followed by desiccation. Red pigments often are apparent in extremely chlorotic leaves.

2,4-D Amine: alkanolamine salt of 2,4-dichlorophenoxyacetic acid

Of the eight herbicides tested, 2,4-D has had the longest and most widespread usage, ranging from pre-emergence soil application to foliar systemic usage. It can be absorbed from the soil by young seedlings causing their destruction, or it can be applied to foliar portions of the plant from which it will translocate into the root area. The 2,4-D compounds are growth regulators which disturb the normal differentiation of tissues causing distortion of plant organs and death if applied in high enough amounts (1). The compounds are most effective against broadleaved plants but will effect grasses at high levels of application.

Varietal Reaction of Crops

Since few experiments have been reported on varietal response of sugarcane to herbicides, it is possible to report on only two such studies. Much has been written about varietal response of corn, sorghum, oats, barley, and wheat to the 2,4-D compounds. Some of these are summarized in this section.

Sugarcane

Nolla (14) applied 2,4-D to fourteen varieties of 6-month-old culms of sugarcane. Effects were measured as degrees curvature of the culm at the growth rings and hypertrophy of the root band. Four varieties were severely injured, two moderately injured, two slightly injured, and six varieties showed considerable resistance.

Studies conducted by Hanson and presented by Denison (3) indicated that the ester, amine, and sodium salt forms of 2,4-D and STCA reduced germination of eight sugarcane varieties tested. Sodium dalapon reduced germination of four varieties. Monuron, diuron, and simazine had no apparent deleterious effect on germination. All chemicals were applied at 5 pounds per acre active material to exposed seed pieces. The same chemicals were applied at the same rate in two post-emergence treatments except that sodium dalapon and STCA were applied only once. Visual observations indicated the most severe effect early in the crop was from 2,4-D ester, dalapon, monuron, 2,4-D amine, diuron, 2,4-D Na salt, and STCA respectively in descending order of effect. Simazine had no apparent deleterious effects on any variety. Damage from other chemicals varied in extent between varieties.

Corn

Viehmeyer (16) studied the effect of 0.25 pound per acre active material of 2,4-D ester on forty commercial or experimental corn varieties. Stalk curvature was measured on 6050 plants. The percentage of stalks seriously affected ranged from 1.40 per cent among tolerant varieties up to 19.22 per cent among susceptible varieties. He indicated a wide degree of range of tolerance existed in these varieties.

Sorghum

The reaction of eight sorghum varieties treated with 0.25, 0.50, and 1 pound per acre of 2,4-D ester at one stage of growth was reported by Elder and Davies (7). Two forage sorghums and two grain sorghums were not affected; one forage and one grain sorghum showed slight reduction in yield when treated with 1 pound per acre of the 2,4-D ester; one grain sorghum had a 45 per cent reduction in yield at the one pound level of treatment; and one grain sorghum had reductions in yield of 55, 33, and 9 per cent from the 1, 0.5, and 0.25 pound levels of treatment respectively.

Elder, Davies, and Dreesen (8) studied the effects of 2,4-D amine at 0.5 and 1 pound per acre, and 2,4-D, 2,4,5-T, and MCPA esters at 1 pound levels when applied to six varieties of combine sorghums. One variety was affected by 1 pound per acre levels of all herbicides. No other varieties were affected.

Gassaway, Davies, and Elder (10) determined tolerance or susceptibility of ten sorghum varieties by measuring the pounds of force required to pull treated plants from the soil after treatment with 0.25, 0.5, and 1 pound per acre of 2,4-D ester. Two varieties had reduced growth and required less force to pull them from the soil than the one known resistant variety. The seven other varieties ranged between the two extremes in force requirements.

In another study, Gassaway, Porter, and Whitfield (11) checked yield results of ten sorghum varieties after treatment with 0.25, 0.5, and 1 pound per acre of 2,4-D ester, and 0.5 pound and 1 pound per acre of 2,4,5-T and MCPA esters. Yields were significantly reduced for four varieties at 1 pound per acre of 2,4-D ester, and for two varieties at 1 pound per acre of 2,4,5-T ester. Other varieties exhibited slight or no yield reductions. MCPA caused a yield reduction of two varieties at the 0.5 pound per acre level and of three varieties at the 1 pound per acre level.

Wheat, Oats, and Barley

Price and Klingman (15) tested twenty-seven wheat and twenty-nine oat varieties with 0.5 pound and 2 pounds per acre of 2,4-D amine at early tillering and fully tillered stages of growth. Varietal response was found in both wheat and oats when 2,4-D was applied at early tillering and in oats when 2,4-D was applied at 2 pounds per acre at the fully tillered stage.

Williams (18) studied the effects of 2,4-D on thirteen oat varieties when the herbicide was applied at 0.5 pound and 1 pound per acre at two stages of growth; initiation of floral primordia and fertilization. Average kernel number was significantly reduced for four varieties. There was a significant variety-stage of application interaction noted for six varieties indicating stage of growth as a factor in 2,4-D effect. The experiment was repeated a second year. Yields of one variety were decreased at one stage in both years, but were decreased in the other stage only one year. Another variety had a reduced yield for two years in two stages. One variety was affected only one year in two stages. Three varieties appeared relatively tolerant during both years of testing. The remaining varieties had intermediate and/or inconsistent response.

Derscheid, Stahler, and Kratochvil (5) conducted an experiment in which nine oat varieties were tested for three years with applications of 2,4-D amine, ester, and Na salt at 1 pound per acre and at three stages of oat plant development. Greatest damage resulted from the 2,4-D ester. Results indicated one variety very susceptible, four varieties less susceptible, and four varieties quite tolerant. Stage of plant growth at the time of herbicide application was the single most important factor involved. In comparing the results of a barley experiment conducted by Derscheid, Stahler, and Kratochvil (4), oats seemed more tolerant than barley when herbicide was applied at certain stages of plant development. The barley experiment was conducted in a manner similar to the oat experiment. Five barley varieties had sharp yield reductions in one year and one variety had reduction of yield all three years from the ester application. Two varieties were quite susceptible to 2,4-D damage, three susceptible, and four were tolerant. Stage of plant growth was again the most important factor related to barley damage from 2,4-D.

Wiebe and Hayes (17) reported the results of application of DDT, a commercial insecticide, to spring and winter barley varieties. Of 107 spring barleys tested, six were found resistant and two were inconsistent in response. All other varieties were killed. No resistant variety was found among the fifty-three winter barleys tested. Testing revealed that resistance to DDT damage is controlled by one single major recessive gene. Only 5 per cent of the commercially grown barley varieties in the United States and Canada were resistant to DDT.

III. METHODS AND MATERIALS

Test Installation

An experiment was installed at Waipio Substation of the Hawaiian Sugar Planters' Association Experiment Station on July 21, 1961. A split-plot design was used. (See Appendix Tables 2 and 3 for analysis of variance for germination and harvest weights respectively).

The main plots were 40 x 15 feet in size, contained eight varietal sub-plots, and were located at random within each of two complete replications. Each main plot received a designation of herbicide and method of application. The eight herbicides discussed in Chapter II were used. At the time of test installation, monuron, diuron, atrazine, dalapon, and 2,4-D amine were in commercial use. The three other herbicides, linuron, prometone, and amitrole were experimental.

Each herbicide was subjected to four methods of application as follows:

Method A. Herbicide applied as pre-emergence chemical over exposed seed pieces at time of cane planting. Seed pieces were placed in the furrow; the herbicide was sprayed over the designated main plots; and the seed pieces were hand covered with soil.

Method B. Same as Method A except that the seed pieces were hand covered before spraying the pre-emergence chemical.

Method C. Seed pieces covered at planting time. Forty-eight days after planting the herbicide was applied as a post-emergence chemical over emerged cane 20-30 inches tall and existing weeds.

Method X. Check - seed pieces covered at planting time. No chemicals applied. Plots were hand weeded forty days after planting when weeds were approximately 8 inches in height.

Method (A) was used to determine what effect herbicides might have on poorly covered seed pieces during pre-emergence applications. Method (B) is the normal plantation practice for pre-emergence weed control. Method (C) was used to determine the effect of post-emergence application when cane is as vulnerable to herbicides as the weeds being sprayed.

The following eight commercial sugarcane varieties were planted: 37-1933; 38-2915; 39-5803; 44-3098; 50-2036; 50-7209; 49-5; and 49-3533. Each was planted into sixty-four, 5 foot by 15 foot sub-plots. One sub-plot of each variety was located at random within each main plot. Seed pieces (vegetative cuttings) were checked for soundness of eyes (nodal buds), counted, and planted at the rate of fifty eyes per plot to facilitate later germination counts. The average seed piece bore three eyes so that planting consisted of approximately seventeen seed pieces per 15 foot plot. Seed pieces received no treatment prior to planting.

Herbicide Application

All herbicides were applied with the HSPA pressure knapsack equipped with a three-nozzle boom using one 9504 and two OC08 teejet tips. Pressure was regulated to deliver 30 psi at the nozzle tips. The application rate was 50 gallons per acre. All herbicides were applied at 5 pounds per acre of active ingredient. Uniform application was achieved by spraying for a time calculated to deliver the proper amount. All spraying times were based on the 5 x 15 foot plot and the delivery rate determined by tip size and pressure.

Cultural Practices

The entire test area was furrow irrigated the day following test installation and at weekly intervals for the next four weeks. Subsequent irrigation during the test period was scheduled at 2-week intervals with adjustment made for rainfall.

The experiment received 75 pounds of nitrogen per acre when the cane was approximately two months old. No other fertilizer was applied during the test period.

Germination Counts, Grading, and Harvesting

Germination counts were made at 2-week intervals following test installation until secondary tillering began. The final counts were recorded for each plot and subjected to an analysis of variance which is reported in Chapter IV.

Weed control ratings were made by the standard HSPA system (20) at 2-week intervals for a period of two months until all treatments were out of control. Visual gradings were also made of cane damage which appeared to result from the herbicide application. Both weed control ratings and cane effect ratings were based on a five index as shown in Table 1. Final ratings are discussed in Chapter IV.

The experiment was harvested at 6 1/3 months just prior to lodging. Each 5 by 15 foot plot was hand cut and bundled. Each bundle was weighed immediately after harvest on a platform scale and recorded. The plot weights obtained included all parts of the cane plant from the ground level up with the exception of loosely adhering dry cane leaves which were stripped in the process of cutting. The cane weight analysis discussed in the next section is based on these plot weights.

TABLE 1

WEED CONTROL AND CANE EFFECT RATINGS (20)

a. Weed Control Rating

Index	Condition
1.0	No apparent control
2.0	Slight control
3.0	Moderate control
4.0	Satisfactory control
5.0	Complete control

b. Cane Effect Rating

Index	Condition
P-5.0[a]	Double the check
P-4.0	Considerably better than check
P-3.0	Moderately better than check
P-2.0	Slightly better than check
1.0	No apparent effect
2.0	Slight effect or chlorosis
3.0	Moderate effect or chlorosis
4.0	Heavy effect or chlorosis
5.0	Plants dead or dying

[a]P = plus value

IV. RESULTS AND DISCUSSION

The results of this experiment are discussed under three major sections: (1) germination count; (2) harvest weights; and (3) weed control and cane effect ratings. The factors of herbicides, methods of application, varieties, and their interactions will be discussed in each of the major sections.

Germination counts and harvest results were subjected to analysis of variance in their original form; however, the coefficient of variability was in the range of 20 per cent for each. In an effort to reduce variability, square root and logarithmic transformations were computed for germination counts and harvest weights respectively. The coefficient of variability was reduced to 11.26 per cent for germination counts and to 4.79 per cent for harvest weights. All results are based on the square root or log. transformations in the following discussions. To show the relationship between original data and transformation data, both are given for the herbicide, method of application, and variety factors, and may be found in the Appendix.

Germination Count

For the discussion on germination only three methods were involved. Methods (A) and (B) were applied at the time of test installation. Method (C) was applied at a later date so that germination in plots designated (C) are in effect check plots and have been included with them for analysis. (Refer to Appendix Table 2 for analysis of variance for germination.)

Herbicidal Effect

Herbicides alone had no significant effect on germination. The range of total counts for the eight herbicides was from 299.2 to 315.8 as shown in Figure 1. Total and average germination counts from the original data may be found in Appendix Table 4.

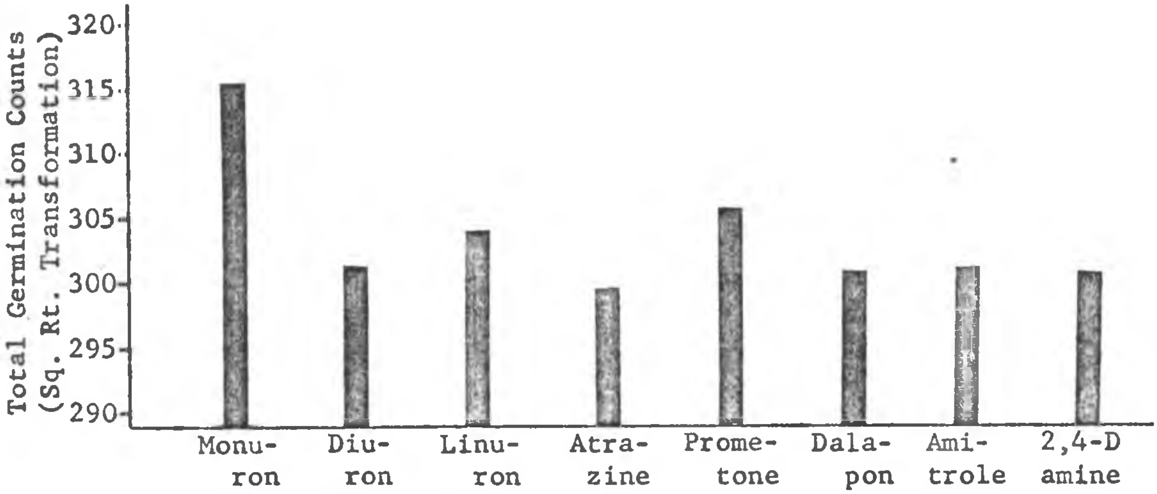

Figure 1. Comparison of Herbicidal Effects on Sugarcane Germination

Method of Application Effect

The method of application factor indicated no significant difference. When divided into the components of (A) + (B) versus check (X), and uncovered application (A) versus covered application (B), no significance was indicated (refer to Appendix Table 5). A study of total germination counts for methods of application (Figure 2) showed a relatively wide range (596.1 to 623.1) between (A) and (B), with (X) at an intermediate count. The application of herbicide over exposed seed (A) caused a slight reduction in over-all germination. The apparent increase in germination with the normal pre-emergence method (B) over the check (X) might be caused by a reduction in weed competition or a stimulative effect from the herbicides applied.

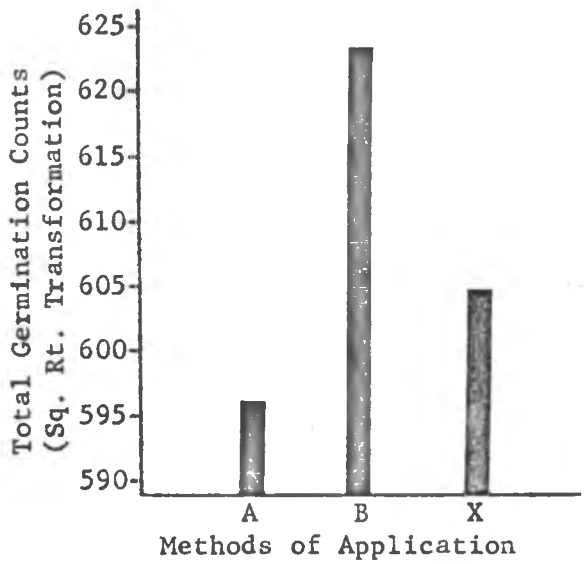

Figure 2. Comparison of Methods of Application Effects on Sugarcane Germination

Herbicide-Method of Application Interaction

The herbicide-method of application interaction was not significant. Comparisons of (A), (B), and (X) methods of application for each herbicide in Figure 3 indicated that when 2,4-D amine was applied over exposed seed (A), germination was reduced. The comparison of means (Appendix Table 6) indicated the (A) versus (B) method of application was significant with 2,4-D amine and substantiated the reduced germination of (A). Dalapon seemed to have a slight inhibitory effect when applied over the soil surface in method (B). The germination plots which received no herbicide application (X) showed little variation between counts.

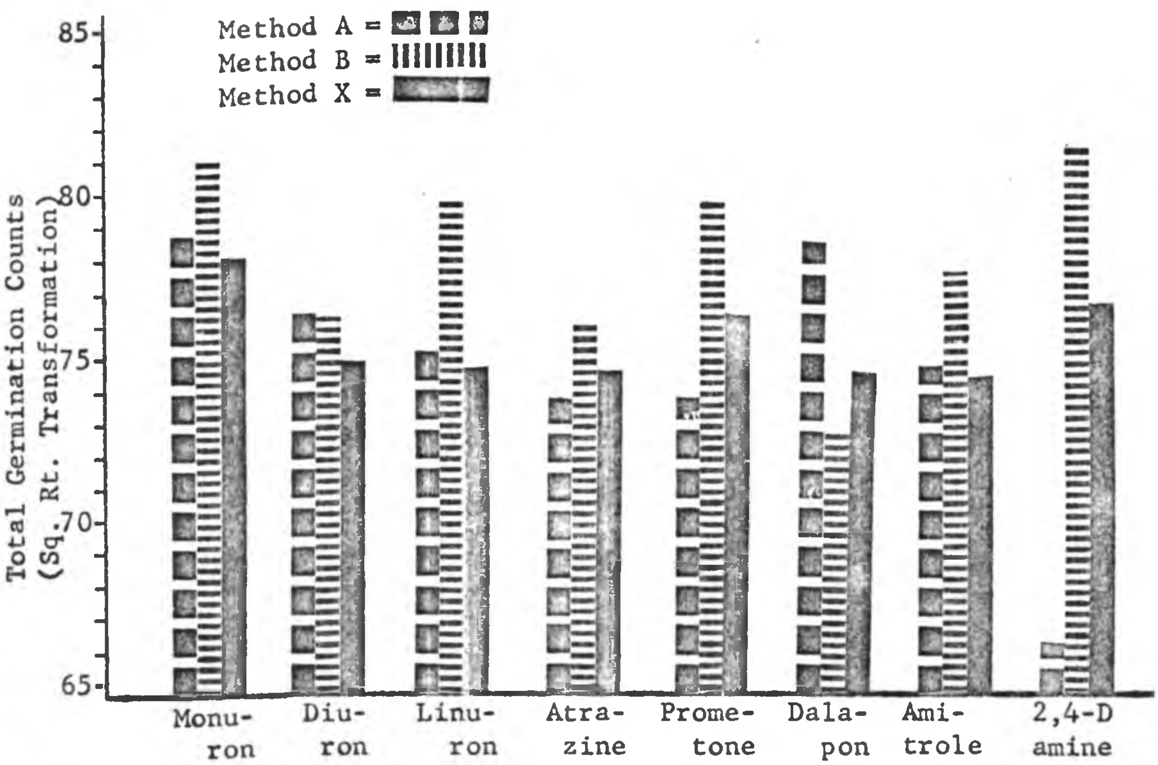

Figure 3. Effect of Herbicide-Method of Application Interaction on Sugarcane Germination

Varietal Effect

Inherent variability between varieties appeared to be the most important factor in obtaining high or low germination counts. The analysis of variance indicated high significance at the 0.01 level for varieties. A study of germination counts as shown in Figure 4 illustrates the relative variability. Varieties 37-1933 and 39-5803 indicated very poor germination, 49-5 and 50-2036 were intermediate, and 38-2915, 44-3098, 49-3533, and 50-7209 germinated equally well. The original germination count totals and averages may be found in Appendix Table 7.

Variety-Herbicide Interaction

The variety-herbicide interaction was indicated to be significant at the 0.05 level. The variety-herbicide data in Table 2 indicates a range in variation within varieties due to herbicides of 2.245 in the least variable variety (50-7209), to 8.764 in the most variable variety (39-5803). The range in variation within herbicides due to varieties was from 18.5 to 20.1. The indicated significance in this interaction is most likely due to variety.

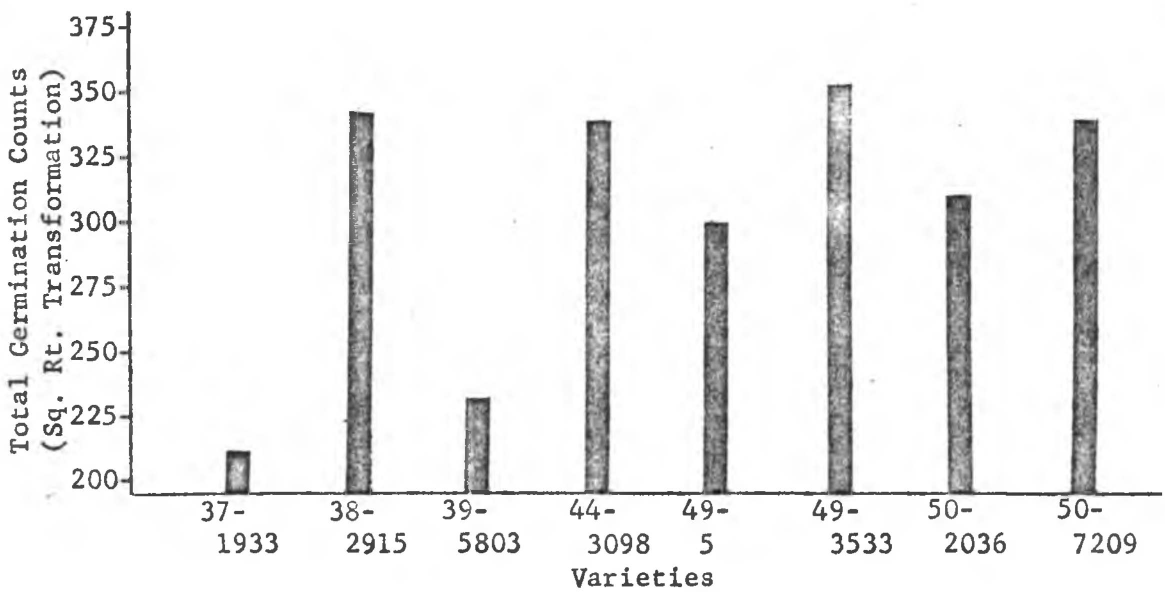

Figure 4. Comparison of Varietal Effects on Sugarcane Germination

Variety-Method of Application Interaction

The variety-method of application interaction was not significant. When separated into components of herbicide application, (A) + (B) versus the check (X), and uncovered seed application (A) versus covered seed application (B), the latter was shown to be significant at the 0.05 level. A further breakdown into comparison of means (Appendix Table 8) indicated significant differences for the (A) + (B) applications versus (X) for varieties 39-5803 and 50-2036 with the check (X) having lowest germination counts. The low counts might have been due to weed

TABLE 2

COMPARISON OF TOTAL GERMINATION COUNTS FOR VARIETY-HERBICIDE INTERACTION (SQUARE ROOT TRANSFORMATION)

Herbicide	Varieties								Average
	37-1933	38-2915	39-5803	44-3098	49-5	49-3533	50-2036	50-7209	
Monuron	25.602	45.412	33.628	43.534	39.941	44.506	39.548	43.594	39.471
Diuron	28.986	43.491	24.864	42.613	37.310	44.306	38.427	42.044	37.755
Linuron	24.250	42.012	32.578	42.729	38.466	41.683	40.961	41.349	38.004
Atrazine	26.755	42.467	26.795	44.590	32.189	45.150	38.447	42.765	37.395
Prometone	25.115	43.505	28.742	43.120	37.934	44.842	39.538	43.294	38.261
Dalapon	27.601	42.582	26.320	41.731	37.043	44.106	37.712	43.362	37.557
Amitrole	23.930	44.014	29.453	41.992	37.539	43.196	37.703	43.239	37.633
2,4-D	24.997	42.812	29.091	41.919	39.129	43.603	35.974	42.808	37.542
Average	25.904	43.287	28.934	42.778	37.444	43.924	38.539	42.806	

competition, although this trend was not true for other varieties. The (A) versus (B) comparison showed variety 50-2036 to be significant. Variety 50-2036 appeared to be stimulated in germination by method of application (B). Although no other varieties exceeded the difference of 0.344 between (A) and (B), all (A) methods of application tended to be slightly lower than (B). This relationship is illustrated in Figure 5.

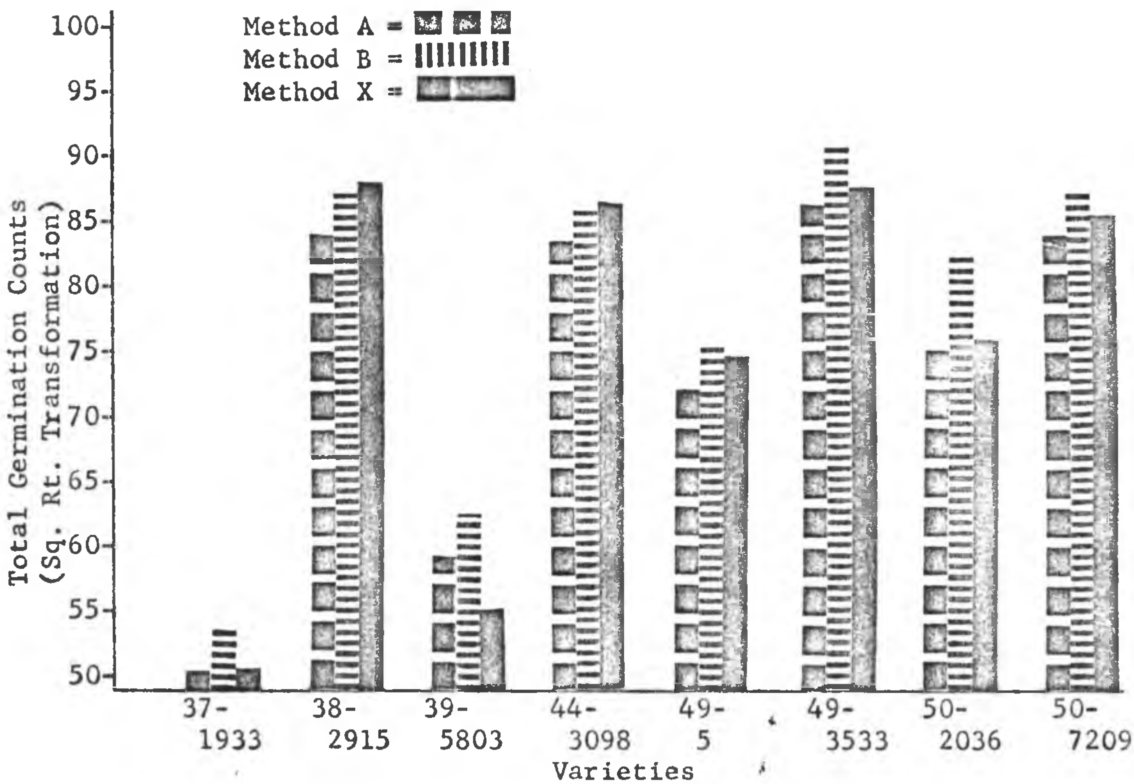

Figure 5. Effect of Variety-Method of Application Interaction on Sugarcane Germination Counts

Variety-Herbicide-Method of Application Interaction

The variety-herbicide-method of application interaction was significant at the 0.05 level. A breakdown into the two comparisons (A) + (B) versus (X) and (A) versus (B), each with 49 degrees of freedom, indicated no significance. A further breakdown of the two comparisons, under varieties, each with 7 degrees of freedom, indicated significant differences to exist between herbicide applications within varieties. The comparison of means for all varieties, in Appendix Table 9, bears out the significant interaction for varieties 37-1933, 39-5803, and 49-5.

Variety 37-1933 had a significant reduction in germination from monuron, linuron, and 2,4-D in the uncovered seed method of application (A), and a significant increase from amitrole, as compared to the covered seed method of application (B). Higher germination counts were obtained from diuron, atrazine, and dalapon in (A) than in (B), and lower counts from prometone in (A) than in (B). The (A) + (B) versus (X) applications were not significant for variety 37-1933.

Variety 39-5803 had a significant reduction in germination from prometone and 2,4-D in the (A) method of application and a significant increase in germination from dalapon when compared to method of application (B). Monuron and 2,4-D caused significant differences in the (A) + (B) versus (X) comparison with the check (X) having lowest germination. The difference might result because of less weed competition in the (A) and (B) plots or from stimulation to the seed piece from the herbicide application.

Variety 49-5 showed significant differences from dalapon and 2,4-D in the (A) versus (B) comparison, with dalapon giving a higher germination count in (A) than in (B), and with 2,4-D acting just in reverse. Atrazine caused a significant difference between (A) + (B) versus (X) comparison indicating a reduction of germination for variety 49-5 when treated with the herbicide.

In variety 50-2036, monuron and linuron caused significant increases in the (A) + (B) applications over the check (X). In comparing (A) versus (B), all herbicides except dalapon caused higher, but nongnificant, germination with the normal post-emergence application (B).

Variety 38-2915 indicated a significant reduction in germination om 2,4-D in both the (A) and (B) methods of application when comred to (X), and in the (A) application when compared to (B).

Varieties 44-3098, 49-3533, and 50-7209 showed no differences tween means great enough to indicate significance.

The interaction between varieties-herbicides-methods of application s too variable to make a general statement regarding one or more ctors, with one exception. In considering application (A) under 2,4-D, l varieties had reduced germination when compared to application (B), d when compared to (X), except variety 39-5803.

Harvest Results

The harvest result data was subjected to a logarithmic transformaon which resulted in a reduced coefficient of variability. The alysis of variance for harvest weights may be found in Appendix Table 3. e methods of application (A), (B), (C), and check (X) all apply in e discussion of harvest results.

rbicidal Effect

The effect of herbicides on total cane weights was of no signifince. A comparison of weights resulting from herbicide applications thout regard to treatments or varieties is presented in Figure 6. is indicated the relatively narrow range of variability between er-all herbicide effects. A comparison of harvest weights from the iginal data may be found in Appendix Table 10.

thod of Application Effects

The method of application effects on total cane weights were highly significant at the 0.01 level. A breakdown into the three possible comparisons of (A) + (B) + (C) versus (X), (A) + (B) versus (C), and (A) versus (B) (Appendix Table 11) indicated that the (A) + (B) versus (C) comparison was significant. This indicated a difference between pre-emergence applications (A) + (B) as compared to post-emergence application (C) in harvest results when herbicides and varieties were not considered. A study of method of application weights in Figure 7 indicated that the post-emergence (C) resulted in the lowest weights.

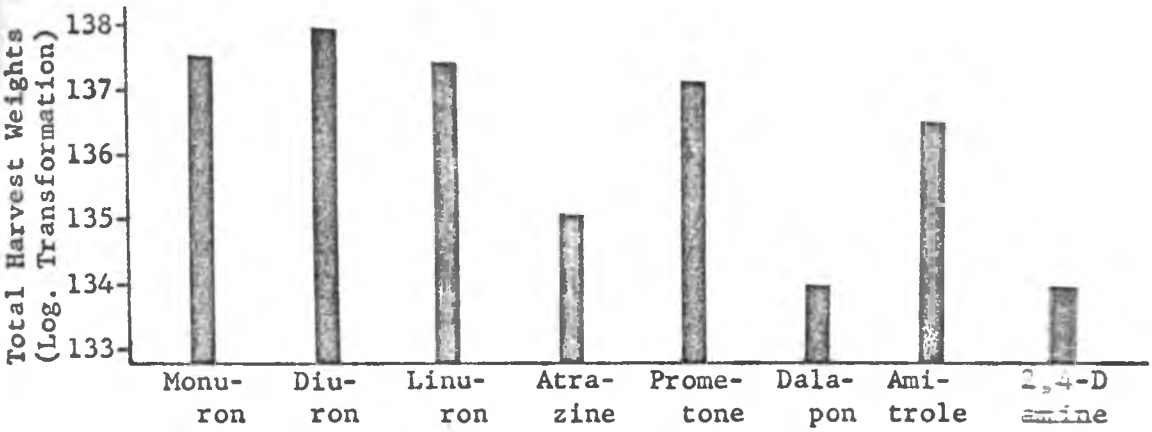

Figure 6. Effect of Herbicides on Sugarcane Harvest Weights

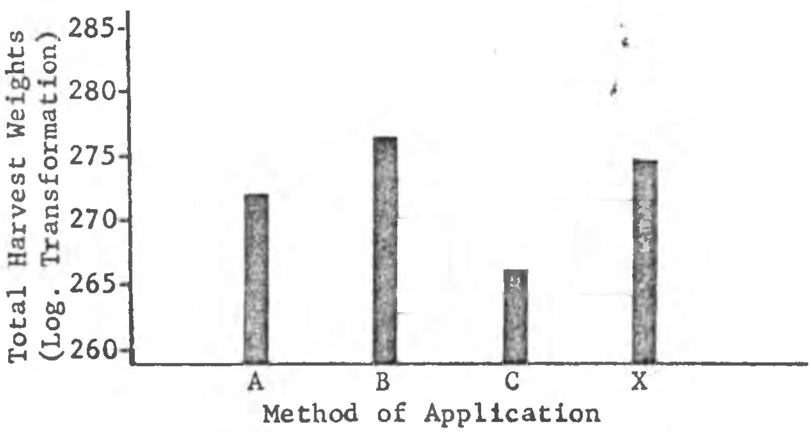

Figure 7. Effect of Method of Application on Sugarcane Harvest Weights

Herbicide-Method of Application Interaction

The interaction of herbicide-method of application was not significant. When the data was subjected to a comparison of means (Appendix Table 12), both dalapon and diuron were significant in the (A) + (B) versus (C) comparison. This indicated a reduction in harvest weights from the post-emergence method of application (C). Comparison of the uncovered seed application (A) versus covered seed application (B) indicated a significant difference with 2,4-D. The (A) method of application resulted in reduced harvest weights. This reduction was most likely caused by the reduced germination early in the crop which was previously reported for 2,4-D. Figure 8 illustrates the reported reductions in yield.

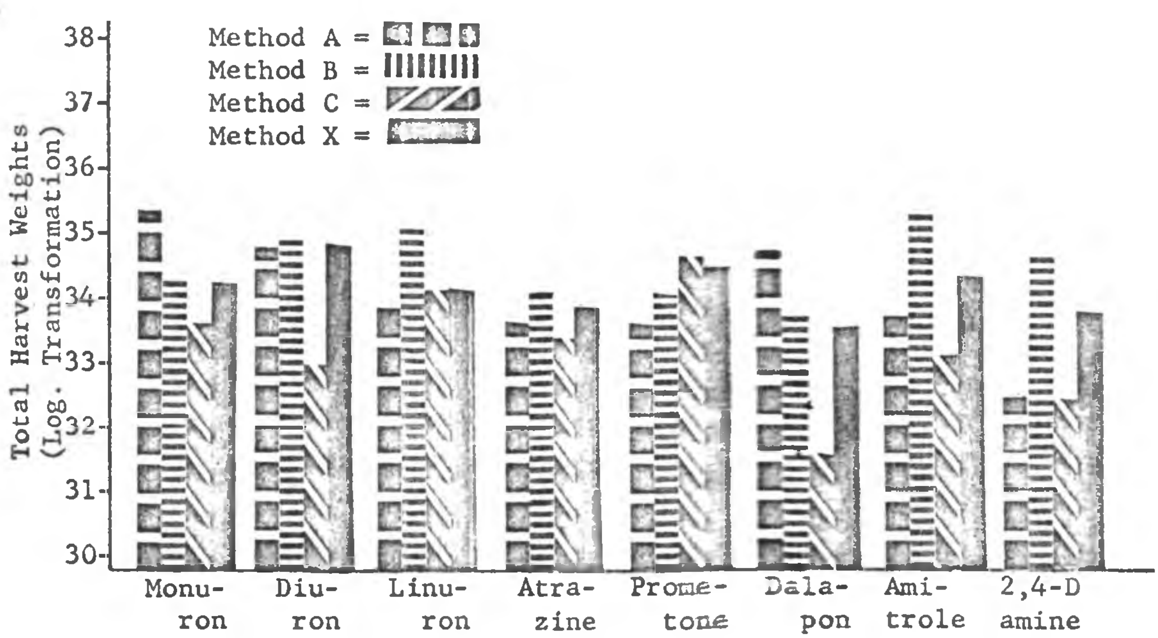

Figure 8. Effect of Herbicide-Method of Application Interaction on Sugarcane Harvest Weights

Varieties

The effect of varieties on harvest weights appeared to be one of the most important factors in this experiment. The variety factor was significant at the 0.01 level. Figure 9 illustrates that varieties 37-1933 and 39-5803 were considerably lower in harvest weights than the remaining six varieties.

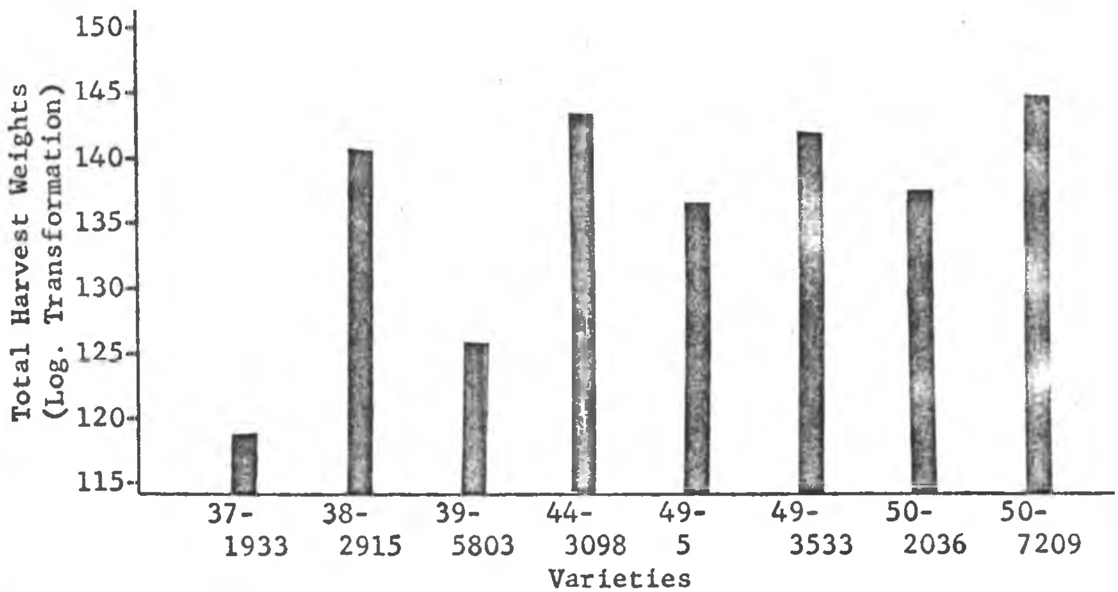

Figure 9. Comparison of Varietal Effects on Sugarcane Harvest Weights

The variety factor was also significant in the germination analysis and the same varieties were low. The corresponding low harvest results for these varieties might be a carry-over from poor germination. The total and average harvest weights from the original data may be found in Appendix Table 13.

Variety-Herbicide Interaction

The variety-herbicide interaction was significant at the 0.05 level. Table 3 gives the harvest weights after transformation. The greatest variability was between varieties within herbicides with a range of difference from 2.851 to 3.992 for atrazine and 2,4-D respectively. Variation between herbicides within varieties was in the order of 0.512 to 1.649 for 44-3098 and 37-1933 respectively.

TABLE 3

COMPARISON OF EFFECTS FOR VARIETY-HERBICIDE INTERACTION ON SUGARCANE HARVEST WEIGHTS (LOG. TRANSFORMATION)

Herbicide	Varieties								Average
	37-1933	38-2915	39-5803	44-3098	49-5	49-3533	50-2036	50-7209	
Monuron	14.976	17.536	16.199	18.196	17.327	17.487	17.126	18.598	17.182
Diuron	15.736	17.912	15.347	17.884	17.231	18.011	17.568	18.206	17.239
Linuron	14.651	17.358	16.018	18.105	17.183	18.136	17.465	18.378	17.163
Atrazine	14.833	17.656	16.202	17.684	16.450	17.533	17.097	17.507	16.872
Prometone	14.818	17.828	15.260	18.068	17.169	17.909	17.601	18.456	17.140
Dalapon	14.482	17.335	15.017	18.015	16.516	17.704	16.941	17.940	16.746
Amitrole	14.596	17.656	16.360	17.826	17.278	17.785	16.961	18.092	17.071
2,4-D	14.087	17.261	15.512	18.079	16.954	17.661	16.828	17.704	16.762
Average	14.772	17.567	15.739	17.982	17.014	17.778	17.197	18.110	

These comparisons tend to indicate that the significant difference shown can be attributed to varietal effects.

Variety-Method of Application Interaction

The variety-method of application interaction was not significant in the analysis of variance or in the breakdown into the treatment combinations. In the comparison of means (Appendix Table 14), the (A) + (B) versus (C) comparison indicated significant differences for varieties 37-1933, 38-2915, 39-5803, 50-2036, and 50-7209. In all cases the post-emergence method of application (C) resulted in low weights. The (C) method of application caused lower weights in the three remaining varieties but the reduction was not significant. Figure 10 illustrates the consistent reduction of method (C) for all varieties.

Variety-Herbicide-Method of Application Interaction

The complex variety-herbicide-method of application interaction was significant at the 0.01 level. Further breakdown of the interaction into (A) + (B) + (C) versus (X), (A) + (B) versus (C), and (A) versus (B) indicated the first two comparisons also to be significant at the 0.01 level. The (A) + (B) comparison did not indicate significance. The comparisons of means for all methods of application are given in Appendix Table 15.

Monuron caused a significant difference only in the pre-emergence methods of application (A) + (B) versus post-emergence application (C) for three varieties. Varieties 39-5803 and 50-2036 had reduced weights in (C), whereas, variety 37-1933 had increased weights for (C). The trend for the remaining varieties was toward higher weights in (A) + (B) methods of application than in (C). In the (A) + (B) + (C) combination, weights tended to be higher than the (X) or untreated weights. In the uncovered seed application (A) weights tended to be higher than in the covered seed application (B).

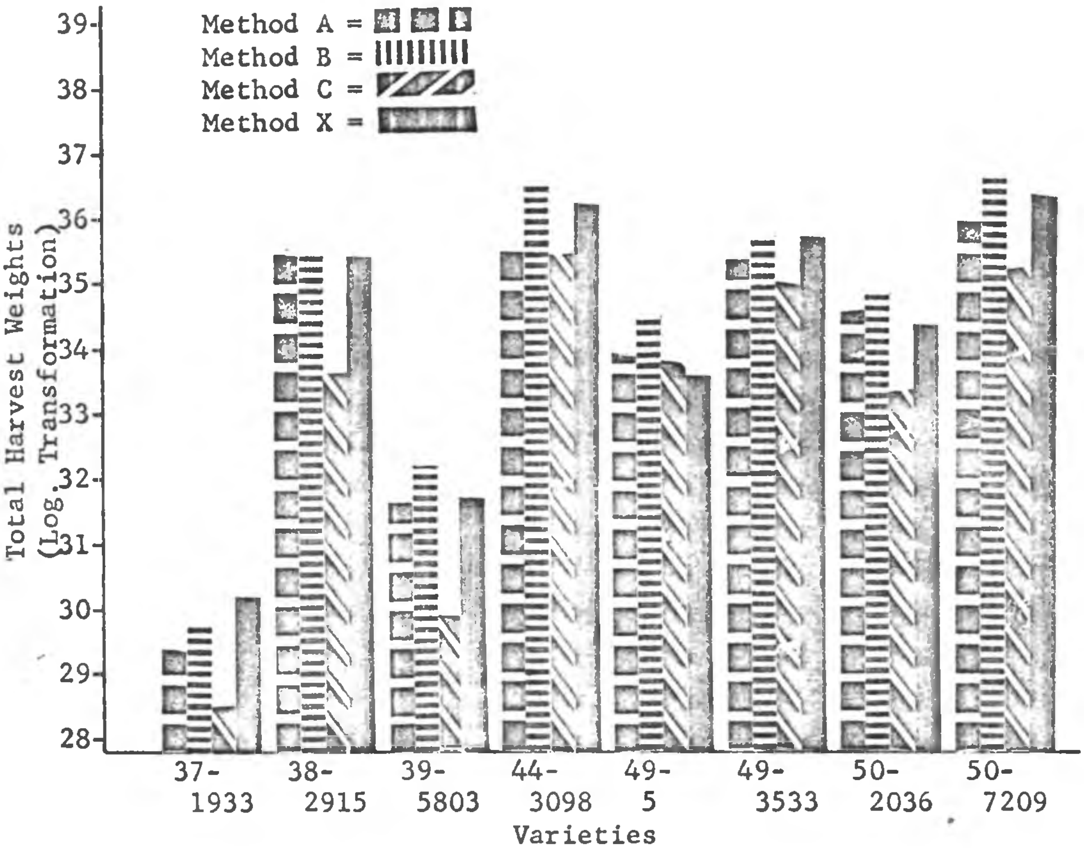

Figure 10. Effect of Variety-Method of Application Interaction on Sugarcane Harvest Weights

With diuron, only one variety, 50-2036, had a significant difference in weights in the (A) + (B) versus (C) comparison in which the (C) weights were low. All other varieties in this comparison were also lower in the (C) method of application as compared to (A) + (B). The (A) + (B) + (C) comparison with (X) showed the (X) weights to be slightly higher. The (A) versus (B) comparison showed no definite trend.

Only variety 37-1933 was significantly affected by linuron in the (A) versus (B) comparison, with (A) having lowest weights. There was a tendency for (B) to be higher than (A) among the other varieties. No trend appeared within the other two comparisons.

A significant difference was exhibited by 37-1933 when treated with atrazine in the (A) + (B) + (C) versus (X) comparison, with (X) giving highest weights. All other varieties except 39-5803 had similar weight differences, but the differences were small. In the (A) + (B) versus (C) comparison, variety 39-5803 was significantly lower in weights in the method of application (C). This trend continued for other varieties. A slight trend existed in the (A) versus (B) comparison, in which the method of application (A) gave lower weights than (B).

In the prometone comparisons, variety 39-5803 was the only one to show significant differences between means. The significance appeared through all comparisons with (A) + (B) + (C) lower than (X), (A) + (B) lower than (C), and (A) lower than (B). Under these circumstances it appears that application of prometone over uncovered seed (A) has caused a significant reduction in yield at approximately seven months of age. The reduction in yield shown by 39-5803 tended to be true for other varieties as well, but was not consistent between varieties or methods of application.

In the (A) + (B) versus (C) comparison, dalapon caused significant differences with varieties 38-2915, 39-5803, 49-5, and 50-7209. The post-emergence method of application (C) had the lowest weights. All remaining varieties also had lower weights in (C). No significance and no trend was shown in the (A) + (B) + (C) versus (X) comparison. In the (A) versus (B) comparison of means, varieties 37-1933 and 39-5803 had significant differences, with (A) having higher weights than (B).

Other varieties exhibited no consistent differences.

Varieties 37-1933 and 38-2915 were significantly affected by amitrole in the (A) + (B) versus (C) comparison, with (C) being lowest. A similar trend was found for all other varieties except 49-3533 and 39-5803. The comparison of (A) + (B) + (C) versus (X) indicated a slight trend favoring (X). In the (A) versus (B) comparison, varieties 44-3098, 49-5, and 50-7209 indicated significant differences with method of application (A) being low. All varieties except 37-1933 followed a similar pattern of differences.

Variety 37-1933 was significantly affected by 2,4-D amine in the (A) + (B) + (C) versus (X) comparison and in the (A) + (B) versus (C) comparison. Yields were lowest where herbicides were applied in both comparisons, and the reductions appeared to be caused by the post-emergence application (C). In the (A) versus (B) comparison, all varieties had lower weights in the uncovered seed method of application (A), with variety 39-5803 indicating significance.

Weed Control and Cane Effect Rating

Weed Control Ratings

Weed control ratings were based on an index given in Table 1 (p. 14). Gradings were made for pre-emergence weed control in the (A), (B), (C), and (X) designated plots, with (C) and (X) being checks for (A) and (B). When the post-emergence application (C) was applied forty-eight days after test installation, gradings were made to determine post-emergence value. Any plots which achieved a satisfactory rating of 4.0 or more, either as pre-emergence or as post-emergence applications, received a recorded "days control" rating equal to the number of days elapsed between test installation and the time that the rating again dropped below 4.0. All plots were graded as 5.0, no weeds, at the time of test installation. Only the herbicide and method of application factors enter into this discussion. Results are reported in Figure 11. Each rating is based on an average of sixteen plots. The most effective herbicides in pre-emergence weed control for the application over uncovered seed (A) are: (1) atrazine; (2) diuron and prometone; (3) monuron and linuron; (4) 2,4-D amine; (5) dalapon and amitrole, in order of control. The last two were no better than the check plot (X).

The normal pre-emergence application (B), showed atrazine and prometone to be best, followed by diuron, monuron, 2,4-D amine, linuron, dalapon, and amitrole, in descending order of control.

In the post-emergence application (C), only diuron and linuron gave effective control. All other herbicides gave some measure of control, but none achieved the 4.0 rating.

Weed species which were present during the test period include the following: Spanish needle, *Bidens pilosa*; smooth amaranth, *Amaranthus hybridus* L.; plush grass, *Chloris radiata*; swollen finger-grass, *Chloris inflata*; wire grass, *Eleusine indica*; flora's paint brush, *Emilia sonchifolia*; crabgrass, *Digitaria spp.*; garden spurge, *Euphorbia hirta*; graceful spurge, *Euphorbia glomerifera*; and purslane, *Portulaca oleracea*.

Cane Effect Ratings

Gradings of cane effect were begun at the time of the post-emergence application (C) and continued for two months. Gradings were based on sugarcane plant chlorosis, stunting, growth abnormalities,

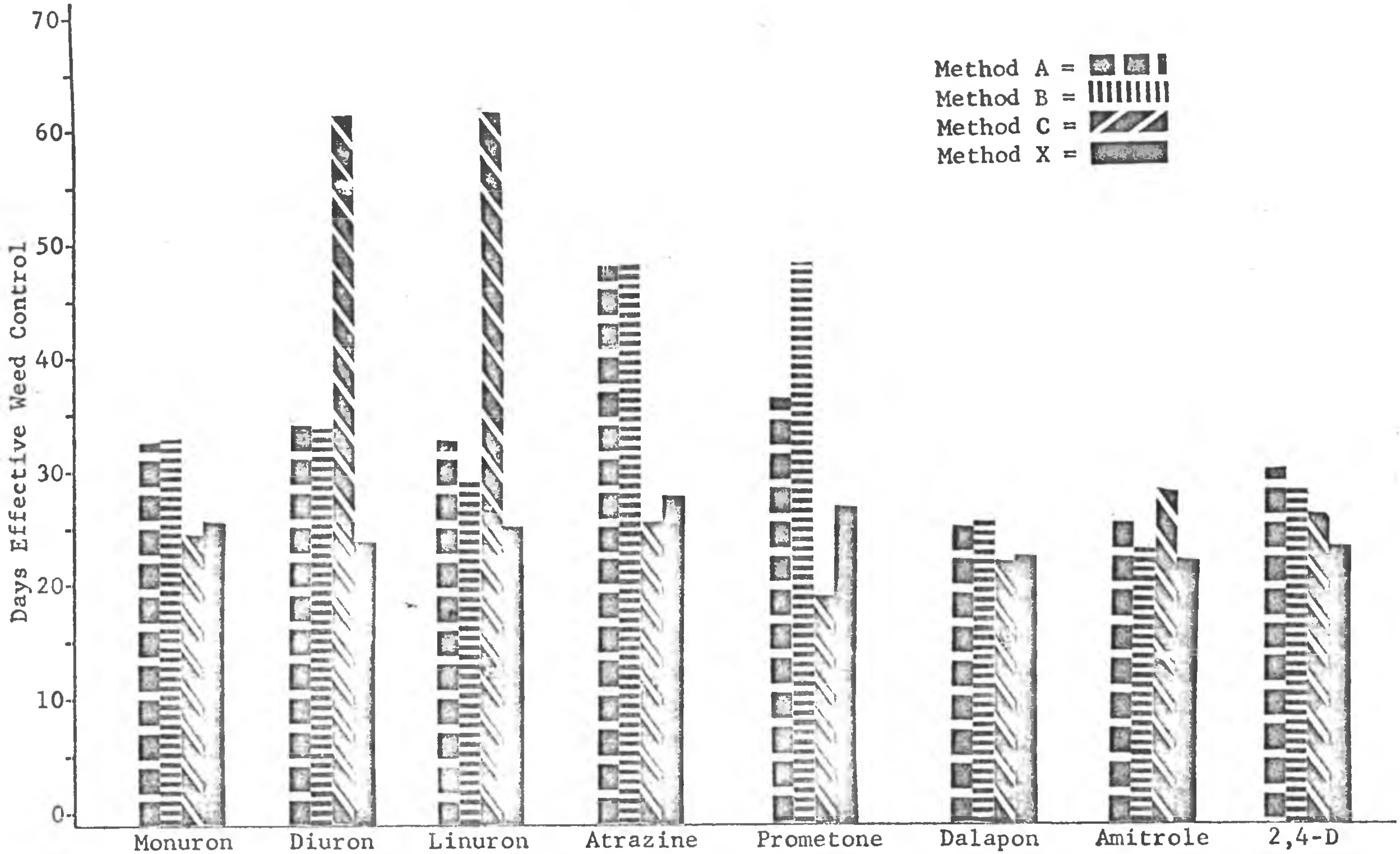

Figure 11. Herbicide Effectiveness for Pre-emergence and Post-emergence Weed Control

reduced tillering, and any other plant characteristic not found under normal growing conditions.

The herbicides which caused the most harmful cane effects were amitrole and dalapon. The effects from these herbicides are also the most obvious of the eight herbicides used. Herbicides linuron, diuron, prometone, and 2,4-D were nearly equal in effect and next in degree of damage to cane. Monuron and atrazine appeared to cause the least damage to sugarcane on the basis of visual observation.

Certain varieties, such as 37-1933 and 39-5803, were more seriously effected by all herbicides than were others. Varieties 38-2915, 50-2036, and 49-5 were next in amount of apparent effect, with nearly all observed damage in the (C) method of application. Varieties 49-3533, 44-3098, and 50-7209 appeared to be unaffected by herbicides other than dalapon and amitrole in the post-emergence application (C).

The most serious effect on cane was caused by the post-emergence application (C). Method of application (A), which received herbicide over exposed seed pieces, was next in order of severity.

The normal pre-emergence application (B) was the least damaging of the methods of herbicide application.

When the final observations of herbicide effect on cane were made, damage to variety 38-2915 was still evident from all herbicides except atrazine and 2,4-D in the post-emergence applications. Other varieties had recovered from all herbicides except in some cases dalapon and amitrole application effects could still be seen.

V. SUMMARY

An experiment was conducted in which eight varieties of sugarcane (37-1933, 38-2915, 39-5803, 44-3098, 49-5, 49-3533, 50-2036, and 50-7209) received eight herbicides (monuron, diuron, linuron, atrazine, prometone, dalapon, amitrole, and 2,4-D amine), in four methods of application: (A) herbicide applied on uncovered seed pieces; (B) herbicide applied on soil after the seed was planted; (C) herbicide applied over sugarcane and weeds when the cane was 20-30 inches high; and (X) the check, or no application of herbicide. The herbicides were all applied at 5 pounds per acre of active ingredient in 50 gallons per acre of spray solution. Germination counts and harvest weights were used to determine the effect of herbicides on sugarcane.

Analysis of germination counts showed the following results:

1. The effect of herbicides and methods of application indicated an over-all reduction in germination from the (A) method of application and a significant reduction when 2,4-D amine was used.
2. Variety effect on germination appeared to be the most important factor in the germination study. Varieties 37-1933 and 39-5803 were poor in germination, varieties 49-5 and 50-2036 were fair in germination, and varieties 38-2915, 44-3098, 49-3533, and 50-7209 were equally good in germina-

tion.

3. A germination difference existed for variety 50-2036 between the (A) and (B) methods of application without regard to herbicide effect.
4. Varieties 44-3098, 49-3533, and 50-7209 were more tolerant of herbicides than were the other five varieties in the germination count studies. Variety 37-1933 was the most susceptible to herbicide damage. Varieties 39-5803, 38-2915, 49-5, and 50-2036 were intermediate in response to herbicides and methods of application.
5. Some herbicides appeared to exert a beneficial effect on germination counts when compared to the checks.

Analysis of harvest weights showed the following results:

1. The post-emergence method of application (C) resulted in a highly significant harvest weight difference when compared to the pre-emergence methods of application (A) + (B).
2. Herbicides alone, without regard to variety or method of application, had no effect on harvest weights.
3. Variety was the most important factor in variation of harvest weights under the conditions of this experiment. Varieties 37-1933 and 39-5803 had the lowest harvest weights, varieties 49-5, 50-2036, and 38-2915 were considerably higher, and varieties 44-3098, 49-3533, and 50-7209 had the highest weights. A trend existed in the variety-method of application interaction for lower harvest weights from the post-emergence application (C) than from the pre-emergence applications (A) and (B).

4. Variety 49-3533 exhibited high tolerance of herbicides for all methods of application, followed closely by varieties 44-3098, 50-7209, 38-2915, 50-2036, and 49-5. Varieties 37-1933 and 39-5803 were most susceptible to herbicide effects under all methods of application. Diuron and linuron were the least damaging herbicides, followed closely by atrazine, monuron, prometone, and 2,4-D. Dalapon and amitrole were the most damaging herbicides under the conditions of this experiment.

Weed control and cane effect ratings showed the following results:

1. Atrazine and prometone were the most effective pre-emergence weed control herbicides in this experiment. Monuron, diuron, and 2,4-D exhibited good pre-emergence weed control. Diuron and linuron were the only effective post-emergence herbicides.
2. Cane effect ratings made on a basis of visual observation showed varieties 44-3098 and 50-7209 to have been least affected by herbicides and methods of application. They were followed by varieties 49-3533, 49-5, 50-2036, 38-2915, 37-1933, and 39-5803 in order of increasing affect. Herbicides which affected sugarcane varieties least were monuron and atrazine, followed by diuron, 2,4-D, prometone, linuron, dalapon, and amitrole in order of increasing affect. The most damaging method of application was the post-emergence application (C), followed by pre-emergence application method (A). Normal pre-emergence application (B) was least damaging.

APPENDIX

APPENDIX TABLE 1

NOMENCLATURE FOR CHEMICALS USED AS HERBICIDES

Chemical Name	Common Name
3-amino-1,2,4-triazole	amitrole
2-chloro-4,6-bis(ethylamino)-s-triazine	simazine
2-chloro-4-ethylamino-6-isopropylamino-s-triazine	atrazine
3-(p-chlorophenyl)1,1-dimethylurea	monuron
2,4-dichlorophenoxyacetic acid	2,4-D
3-(3,4-dichlorophenyl)-1,1-dimethylurea	diuron
3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea	linuron
2,2-dichloropropionic acid	dalapon
2-methoxy-4,6-bis(isopropylamino)-s-triazine	prometone
2-methyl-4-chlorophenoxyacetic acid	MCPA
trichloroacetic acid	TCA
2,4,5-trichlorophenoxyacetic acid	2,4,5-T

APPENDIX TABLE 2

ANALYSIS OF VARIANCE - SQUARE ROOT TRANSFORMATION OF GERMINATION DATA

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Main plots:			
Replications	1	.276	.276
Plots	23	15.136	.658
Herbicides (H)	7	3.180	.454
Methods of Application (M)	2	3.028	1.514
H x M	14	8.928	.638
Error (a)	39	27.718	.711
Sub-plots:			
Varieties (V)	7	338.062	48.295**
V x H	49	17.583	.359*
V x M	14	4.161	.297
V x H x M	98	31.760	.324*
Error (b)	280	69.217	.247

*Significant at 0.05 level.
**Significant at 0.01 level.
C.V. = 11.26 per cent.

APPENDIX TABLE 3

ANALYSIS OF VARIANCE - LOG. TRANSFORMATION OF HARVEST WEIGHTS

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square
Main plots:			
Replications	1	.002	.002
Plots	31	1.386	.045
Herbicides (H)	7	.275	.039
Methods of Application (M)	3	.469	.156**
H x M	21	.642	.031
Error (a)	31	.918	.030
Sub-plots:			
Varieties (V)	7	9.249	1.321**
V x H	49	.582	.012*
V x M	21	.183	.009
V x H x M	147	2.233	.015**
Error (b)	224	1.734	.008

*Significant at 0.05 level.
**Significant at 0.01 level.
C.V. = 4.79 per cent.

APPENDIX TABLE 4

COMPARISON OF HERBICIDAL EFFECTS ON SUGARCANE GERMINATION (ORIGINAL DATA)

Germ. Counts	Herbicides							
	Monuron	Diuron	Linuron	Atrazine	Prometone	Dalapon	Amitrole	2,4-D amine
Total	1594	1461	1489	1446	1502	1448	1455	1451
Average (n = 64)	24.91	22.83	23.26	22.59	23.47	22.62	22.73	22.67

APPENDIX TABLE 5

COMPARISON OF MEANS FOR METHOD OF APPLICATION EFFECTS ON SUGARCANE GERMINATION COUNTS

Methods of Application	Mean Germ. Count (Square Root Transformation)	Germ. Count (Original Data)	
		Average	Total
A + B X (n = 256)	4.76 4.73 - $HSD_{.05}$ = .153	23.27 23.01	5956 5890
A B (n = 128)	4.66 4.87 - $HSD_{.05}$ = .723	22.34 30.97	2859 3097

APPENDIX TABLE 6

COMPARISON OF MEANS FOR HERBICIDE-METHOD OF APPLICATION INTERACTION ON SUGARCANE GERMINATION COUNTS (SQUARE ROOT TRANSFORMATION)

Method of Application	Herbicides							
	Monuron	Diuron	Linuron	Atrazine	Prometone	Dalapon	Amitrole	2,4-D amine
A + B	4.987	4.761	4.829	4.669	4.790	4.709	4.755	4.601
X	4.880	4.678	4.672	4.680	4.775	4.680	4.653	4.784
(n = 32)	-	-	-	-	-	-	-	-
	$HSD_{.05}$ = .427							
A	4.916	4.765	4.686	4.593	4.604	4.888	4.680	4.126*
B	5.058	4.756	4.972	4.745	4.976	4.530	4.831	5.076
(n = 16)	-	-	-	-	-	-	-	(.950)
	$HSD_{.05}$ = .604							

*Significant at 0.05 level.

APPENDIX TABLE 7

COMPARISON OF VARIETAL EFFECT ON SUGARCANE GERMINATION (ORIGINAL DATA)

Germ. Counts	Varieties							
	37-1933	38-2915	39-5803	44-3098	49-3533	49-5	50-2036	50-7209
Total	682	1860	856	1813	1918	1408	1479	1830
Average (n = 64)	10.66	29.06	13.38	28.33	29.97	22.00	23.11	28.59

APPENDIX TABLE 8

COMPARISON OF MEANS FOR VARIETY-METHOD OF APPLICATION INTERACTION ON SUGARCANE GERMINATION COUNTS (SQUARE ROOT TRANSFORMATION)

Method of Application	Varieties							
	37-1933	38-2915	39-5803	44-3098	49-5	49-3533	50-2036	50-7209
A + B X (n = 32)	3.236 3.240 - HSD$_{.05}$ = .243	5.338 5.484 -	3.793* 3.440 (.353)	5.292 5.402 -	4.654 4.708 -	5.492 5.489 -	4.943* 4.692 (.251)	5.354 5.348 -
A B (n = 16)	3.128 3.345 - HSD$_{.05}$ = .344	5.247 5.428 -	3.678 3.909 -	5.265 5.320 -	4.601 4.706 -	5.336 5.648 -	4.731* 5.154 (.423)	5.271 5.436 -

*Significant at 0.05 level.

APPENDIX TABLE 9

COMPARISON OF MEANS FOR VARIETY-HERBICIDE-METHOD OF APPLICATION INTERACTION FOR SUGARCANE GERMINATION COUNTS

Variety	Treat-ment	Herbicides							
		Monuron	Diuron	Linuron	Atrazine	Prometone	Dalapon	Amitrole	2,4-D
37-1933	A+B	2.964	3.532	2.858	3.510	3.449	3.148	3.310	3.123
	X	3.437	3.714	3.205	3.178	2.830	3.752	2.672	3.126
		-	-	-	-	-	-	-	-
38-2915	A+B	5.687	5.477	5.031	5.302	5.369	5.296	5.548	4.993*
	X	5.666	5.396	5.472	5.315	5.507	5.350	5.455	5.710
		-	-	-	-	-	-	-	(.717)
39-5803	A+B	4.788*	3.322	4.238	3.298	3.365	3.458	3.782	4.096*
	X	3.618	2.894	3.907	3.401	3.820	3.122	3.580	3.176
		(1.170)	-	-	-	-	-	-	(.920)
44-3098	A+B	5.300	5.176	5.408	5.617	5.302	5.180	5.340	4.999
	X	5.584	5.463	5.274	5.530	5.477	5.253	5.157	5.480
		-	-	-	-	-	-	-	-
49-5	A+B	4.914	4.853	4.823	3.496*	4.937	4.760	4.856	4.588
	X	5.070	4.474	4.793	4.551	4.546	4.501	4.528	5.194
		-	-	-	(1.055)	-	-	-	-
49-3533	A+B	5.666	5.493	5.411	5.599	5.550	5.615	5.226	5.376
	X	5.460	5.583	5.010	5.688	5.661	5.412	5.573	5.524
		-	-	-	-	-	-	-	-
50-2036	A+B	5.323*	4.853	5.363*	4.981	5.098	4.860	4.632	4.430
	X	4.563	4.877	4.631	4.786	4.567	4.794	4.563	4.794
		(.760)	-	(.732)	-	-	-	-	-
50-7209	A+B	5.254	5.365	5.503	5.550	5.250	5.360	5.347	5.202
	X	5.644	5.146	4.834	5.141	5.573	5.481	5.463	5.500
		-	-	-	-	-	-	-	-

$HSD_{.05}$= .688 *indicates significant interactions

(Continued

APPENDIX TABLE 9 - Continued

Variety	Treat-ment	Herbicides							
		Monuron	Diuron	Linuron	Atrazine	Prometone	Dalapon	Amitrole	2,4-D
37-1933	A	2.421*	3.719	2.128*	3.613	3.116	3.491	4.044*	2.492*
	B	3.506	3.346	3.587	3.407	3.782	2.804	2.576	3.754
		(1.085)	-	(1.459)	-	-	-	(1.468)	(1.262)
38-2915	A	5.776	5.400	5.184	5.277	5.412	5.126	5.508	4.297*
	B	5.598	5.554	4.879	5.826	5.326	5.465	5.590	5.689
		-	-	-	-	-	-	-	(1.392)
39-5803	A	5.181	3.119	4.079	3.253	2.731*	4.207*	3.646	3.205*
	B	4.396	3.524	4.396	3.342	3.999	2.708	3.918	4.987
		-	-	-	-	(1.268)	(1.499)	-	(1.782)
44-3098	A	5.372	5.254	5.548	5.683	5.232	4.987	5.274	4.768
	B	5.228	5.126	5.269	5.552	5.372	5.372	5.407	5.230
		-	-	-	-	-	-	-	-
49-5	A	4.612	5.033	4.816	3.486	4.728	5.412*	4.676	4.044*
	B	5.218	4.674	4.830	3.506	5.145	4.107	5.036	5.132
		-	-	-	-	-	(1.305)	-	(1.088)
49-3533	A	5.556	5.461	5.134	5.465	5.499	5.504	5.084	4.987
	B	5.726	5.525	5.687	5.733	5.600	5.725	5.368	5.766
		-	-	-	-	-	-	-	-
50-2036	A	5.228	4.674	5.326	4.501	4.834	4.928	4.279	4.079
	B	5.418	5.033	5.400	5.460	5.363	4.794	4.984	4.782
		-	-	-	-	-	-	-	-
50-7209	A	5.183	5.460	5.274	5.463	5.277	5.450	4.927	5.135
	B	5.325	5.269	5.732	5.636	5.224	5.269	5.766	5.269
		-	-	-	-	-	-	-	-

$HSD_{.05} = .974$

APPENDIX TABLE 10

COMPARISON OF HERBICIDAL EFFECTS ON SUGARCANE WEIGHTS (ORIGINAL DATA)

Harvest Weights	Herbicides							
	Monu-ron	Diu-ron	Linu-ron	Atra-zine	Prome-tone	Dala-pon	Ami-trole	2,4-D amine
Total	9587	9762	9509	8727	9593	8652	9386	8631
Average (n = 64)	149.8	152.5	148.6	136.4	149.9	135.2	146.7	134.9

APPENDIX TABLE 11

COMPARISON OF MEANS FOR METHOD OF APPLICATION EFFECTS ON SUGARCANE WEIGHTS

Methods of Application	Harvest Weight Means (Log. Transformation)	Harvest Weights - Original Data	
		Total	Average
A + B + C	2.122	54902	142.97
X	2.144	18945	148.01
	-		
	$HSD_{.05}$ = .036		
A + B	2.144*	38264	149.47
C	2.079	16638	129.98
	(.065)		
	$HSD_{.05}$ = .038		
A	2.128	18526	144.73
B	2.160	19738	154.20
	-		
	$HSD_{.05}$ = .044		

*Significant at 0.05 level.

APPENDIX TABLE 12

COMPARISON OF MEANS FOR HERBICIDE-METHOD OF APPLICATION INTERACTION ON SUGARCANE HARVEST WEIGHTS (LOG. TRANSFORMATION)

Method of Application	Herbicides							
	Monuron	Diuron	Linuron	Atrazine	Prometone	Dalapon	Amitrole	2,4-D amine
A+B+C	2.151	2.144	2.148	2.102	2.131	2.086	2.128	2.087
X	2.139	2.186	2.136	2.129	2.178	2.115	2.151	2.121
	-	-	-	-	-	-	-	-
	$HSD_{.05}$ = .102							
A+B	2.175	2.183*	2.159	2.112	2.110	2.142*	2.156	2.114
C	2.103	2.068	2.128	2.082	2.172	1.972	2.072	2.033
	-	(.115)	-	-	-	(.170)	-	-
	$HSD_{.05}$ = .110							
A	2.206	2.179	2.127	2.092	2.092	2.169	2.109	2.049*
B	2.143	2.186	2.190	2.132	2.129	2.116	2.203	2.178
	-	-	-	-	-	-	-	(.129)
	$HSD_{.05}$ = .125							

*Significant at 0.05 level.

APPENDIX TABLE 13

COMPARISON OF VARIETAL EFFECT ON SUGARCANE HARVEST WEIGHTS
(ORIGINAL DATA)

Harvest Weights	Varieties							
	37-1933	38-2915	39-5803	44-3098	49-5	49-3533	50-2036	50-7209
Total	4762	10320	6378	11485	8815	10826	9205	12056
Average (n = 64)	74.41	161.25	99.66	179.45	137.73	169.16	143.83	188.38

APPENDIX TABLE 14

COMPARISON OF MEANS FOR VARIETY-METHOD OF APPLICATION INTERACTION ON SUGARCANE HARVEST WEIGHTS (LOG. TRANSFORMATION)

Method of Application	Varieties							
	37-1933	38-2915	39-5803	44-3098	49-5	49-3533	50-2036	50-7209
A+B+C	1.842	2.188	1.959	2.244	2.132	2.216	2.148	2.257
X	1.891	2.220	1.993	2.259	2.112	2.241	2.154	2.284
	-	-	-	-	-	-	-	-
	$HSD_{.05}$=	.051						
A+B	1.850*	2.224*	2.003*	2.255	2.140	2.225	2.177*	2.275*
C	1.796	2.116	1.871	2.223	2.115	2.198	2.091	2.220
	(.054)	(.108)	(.132)	-	-	-	(.086)	(.055)
	$HSD_{.05}$=	.054						
A	1.833	2.228	1.983	2.230	2.119	2.212	2.168	2.249
B	1.867	2.220	2.022	2.279	2.160	2.238	2.186	2.302
	-	-	-	-	-	-	-	-
	$HSD_{.05}$=	.062						

*Significant at 0.05 level.

APPENDIX TABLE 15

COMPARISON OF MEANS FOR VARIETY-HERBICIDE-METHOD OF APPLICATION INTERACTION FOR SUGARCANE HARVEST WEIGHTS (LOGARITHMIC TRANSFORMATION)

Herbicide	Treat-ment	Varieties							
		37-1933	38-2915	39-5803	44-3098	49-5	49-3533	50-2036	50-7209
Monuron	A+B+C	1.864	2.193	2.025	2.268	2.173	2.197	2.142	2.341
	X	1.896	2.190	2.024	2.294	2.144	2.152	2.138	2.276
		-	-	-	-	-	-	-	-
Diuron	A+B+C	1.940	2.226	1.906	2.244	2.164	2.235	2.182	2.256
	X	2.048	2.277	1.956	2.210	2.124	2.300	2.238	2.334
		-	-	-	-	-	-	-	-
Linuron	A+B+C	1.8.2	2.201	2.002	2.274	2.146	2.271	2.182	2.298
	X	1.889	2.076	2.004	2.231	2.152	2.256	2.186	2.296
		-	-	-	-	-	-	-	-
Atrazine	A+B+C	1.810*	2.204	2.058	2.203	2.048	2.171	2.135	2.187
	X	1.988	2.216	1.926	2.234	2.081	2.252	2.144	2.192
		(.178)	-	-	-	-	-	-	-
Prometone	A+B+C	1.860	2.223	1.851*	2.243	2.154	2.234	2.181	2.298
	X	1.829	2.243	2.076	2.304	2.123	2.252	2.258	2.334
		-	-	(.225)	-	-	-	-	-
Dalapon	A+B+C	1.811	2.144	1.845	2,236	2.074	2.240	2.144	2.222
	X	1.807	2.237	1.873	2.298	2.037	2.226	2.039	2.303
		-	-	-	-	-	-	-	-
Amitrole	A+B+C	1.859	2.178	2.036	2.219	2.169	2.211	2.110	2.239
	X	1.722	2.292	2.072	2.256	2.132	2.260	2.150	2.328
		-	-	-	-	-	-	-	-
2,4-D	A+B+C	1.699*	2.135	1.948	2.266	2.124	2.200	2.110	2.213
	X	1.948	2.224	1.914	2.243	2.106	2.232	2.083	2.214
		(.249)	-	-	-	-	-	-	-

$HSD_{.05}$= .143 *indicates significant interaction

(Continued

APPENDIX TABLE 15 - Continued

Herbicide	Treat-ment	Varieties							
		37-1933	38-2915	39-5803	44-3098	49-5	49-3533	50-2036	50-7209
Monuron	A+B	1.806*	2.241	2.107*	2.314	2.146	2.210	2.198*	2.372
	C	1.980	2.096	1.862	2.176	2.229	2.172	2.029	2.280
		(.174)	-	(.245)	-	-	-	(.169)	-
Diuron	A+B	1.965	2.276	1.955	2.267	2.213	2.265	2.249*	2.269
	C	1.890	2.126	1.808	2.198	2.066	2.176	2.048	2.231
		-	-	-	-	-	-	(.201)	-
Linuron	A+B	1.828	2.211	2.040	2.272	2.135	2.270	2.205	2.305
	C	1.780	2.181	1.926	2.277	2.169	2.271	2.137	2.282
		-	-	-	-	-	-	-	-
Atrazine	A+B	1.827	2.207	2.127*	2.209	2.034	2.186	2.144	2.160
	C	1.775	2.197	1.921	2.190	2.077	2.141	2.115	2.241
		-	-	(.206)	-	-	-	-	-
Prometone	A+B	1.840	2.211	1.770*	2.215	2.138	2.217	2.191	2.295
	C	1.900	2.248	2.014	2.300	2.184	2.268	2.160	2.304
		-	-	(.244)	-	-	-	-	-
Dalapon	A+B	1.796	2.207*	2.002*	2.258	2.161*	2.246	2.162	2.306*
	C	1.843	2.016	1.531	2.193	1.900	2.134	2.108	2.054
		-	(.191)	(.471)	-	(.261)	-	-	(.252)
Amitrole	A+B	1.924*	2.289*	2.028	2.220	2.204	2.199	2.134	2.248
	C	1.730	1.958	2.052	2.218	2.100	2.235	2.064	2.221
		(.194)	(.331)	-	-	-	-	-	-
2,4-D	A+B	1.814*	2.148	1.994	2.282	2.088	2.205	2.131	2.246
	C	1.467	2.110	1.856	2.232	2.195	2.189	2.070	2.148
		(.347)	-	-	-	-	-	-	-

$HSD_{.05}$ = .152 *indicates significant interaction

(Continued

APPENDIX TABLE 15 - Continued

Herbicide	Treat-ment	Varieties							
		37-1933	38-2915	39-5803	44-3098	49-5	49-3533	50-2036	50-7209
Monuron	A	1.812	2.286	2.162	2.360	2.113	2.287	2.223	2.402
	B	1.800	2.197	2.052	2.268	2.178	2.133	2.174	2.342
		-	-	-	-	-	-	-	-
Diuron	A	1.955	2.247	1.966	2.231	2.276	2.240	2.218	2.296
	B	1.974	2.306	1.944	2.303	2.150	2.289	2.281	2.242
		-	-	-	-	-	-	-	-
Linuron	A	1.684*	2.258	1.981	2.228	2.134	2.246	2.228	2.258
	B	1.972	2.165	2.098	2.316	2.136	2.294	2.182	2.353
		(.288)	-	-	-	-	-	-	-
Atrazine	A	1.777	2.248	2.186	2.177	1.980	2.163	2.112	2.094
	B	1.877	2.166	2.068	2.241	2.088	2.210	2.178	2.227
		-	-	-	-	-	-	-	-
Prometone	A	1.785	2.249	1.642*	2.244	2.118	2.207	2.188	2.299
	B	1.895	2.174	1.899	2.187	2.158	2.228	2.195	2.291
		-	-	(.257)	-	-	-	-	-
Dalapon	A	1.892*	2.159	2.107*	2.233	2.208	2.242	2.206	2.306
	B	1.700	2.255	1.898	2.284	2.114	2.250	2.118	2.307
		(.192)	-	(.209)	-	-	-	-	-
Amitrole	A	2.006	2.278	1.982	2.127*	2.087*	2.138	2.096	2.154*
	B	1.840	2.301	2.074	2.313	2.321	2.260	2.172	2.343
		-	-	-	(.186)	(.234)	-	-	(.189)
2,4-D	A	1.750	2.098	1.840*	2.244	2.037	2.167	2.075	2.180
	B	1.879	2.197	2.147	2.322	2.139	2.243	2.186	2.311
		-	-	(.307)	-	-	-	-	-

$HSD_{.05}$ = .175

LITERATURE CITED

Books

1. CRAFTS, A.S. The Chemistry and Mode of Action of Herbicides. Interscience Publishers, New York - London. 1961.

Articles and Periodicals

2. CRAFTS, A.S., and FOY, C.L. Autoradiography of Radioactive Dalapon. Down To Earth. Spring. 1959.

3. DENISON, F.C. Varietal Reaction to Herbicides. Reports of Hawaiian Sugar Technologists. 19:234-237. 1960.

4. DERSCHEID, LYLE A., STAHLER, L.M., and KRATOCHVIL, D.E. Differential Responses of Barley Varieties to 2,4-Dichlorophenoxyacetic Acid (2,4-D). Agron. Jour. 44:182-188. 1952.

5. DERSCHEID, LYLE A., STAHLER, L.M., and KRATOCHVIL, D.E. Differential Responses of Oat Varieties to 2,4-Dichlorophenoxyacetic Acid (2,4-D). Agron. Jour. 45:11-17. 1953.

6. ECKART, C.F. Report of the Committee on Cultivation and Fertilization on Unirrigated Plantations. The Hawaiian Planters Record. 10(2):101-105. 1914.

7. ELDER, W.C., DAVIES, FRANK F. Response of Sorghum Varieties to 2,4-D at One Stage of Growth. Res. Report NCWCC. 5:80. 1948.

8. ELDER, W.C., DAVIES, FRANK F., and DREESEN, JACK. Tolerance of Combine Sorghums to 2,4-D, 2,4,5-T, and MCP. Res. Report NCWCC. 9:99. 1952.

9. FUNDERBURK, H.H., JR., and DAVIS, D.E. Factors Affecting the Response of *Zea mays* and *Sorghum halepense* to Sodium 2,2-Dichloropropionate. Weeds. 8:6-11. 1960.

10. GASSAWAY, JAMES E., DAVIES, FRANK F., and ELDER, W.C. Response of Ten Sorghum Varieties to 2,4-D Treatments. Res. Report NCWCC. 7:107. 1950

11. GASSAWAY, JAMES E., PORTER, KENNETH B., and WHITFIELD, CHARLES J. Response of Ten Sorghum Varieties to 2,4-D, 2,4,5-T, and MCP Treatments. Res. Report NCWCC. 9:99. 1952.

12. GYSIN, H., and KNUSLI, E. Activity and Mode of Action of Triazine Herbicides. British Weed Control Conf. Proc. 4th Meeting:225-233. 1958.

13. GYSIN, H. and KNUSLI, E. Chemistry and Herbicidal Properties of Triazine Derivatives. British Weed Control Conf. Proc. 3rd Meeting: 615-623. 1956.

14. NOLLA, J.A.B. Injury to Sugarcane from 2,4-D. Int. Soc. Sugar Cane Tech. Proc. 178-189. 1950.

15. PRICE, C.D., and KLINGMAN, G.C. Wheat and Oats Varietal Response to Applications of Alkanolamine Salt of 2,4-D. Agron. Jour. 50:200-204. 1958.

16. VIEHMEYER, GLENN. Varietal Response of Forty Corn Hybrids to 2,4-D. Res. Report NCWCC. 5:78. 1948.

17. WIEBE, G.A., and HAYES, J.D. The Role of Genetics in the Use of Agricultural Chemicals. Agron. Jour. 52(12):685-686. 1960.

18. WILLIAMS, JAMES H. Differential Varietal Response of Oat Varieties to 2,4-Dichlorophenoxyacetic Acid. Agron. Jour. 46:565-569. 1954.

19. YUEN, QUAN H., and HILTON, H. WAYNE. The Adsorption of Monuron and Diuron by Hawaiian Sugarcane Soils. Ag. and Food Chem. 10(5):386-392. 1962.

Manuals

20. Weed Control Manual for the Hawaiian Sugar Industry. p. 87. January. 1962.